Mariner Venus-Mercury 1973 Mission Support

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During September and October 1973, priority was given to support of Project Mission Operations System tests. DSN performance during these tests was less than satisfactory in many cases. Therefore, a significant level of effort was devoted to DSN problem isolation and resolution. Progress on open implementation tasks also continued.

I. Planning Activities

A. NASA Support Plan

The NASA Support Plan (NSP) for MVM'73 has been revised and resubmitted to NASA Headquarters for approval. This revision is consistent with current requirements, plans, and agreements. Update of the NSP at this time followed recent DSN Operational Readiness and Status Reviews. Therefore, the NSP contains actual, final support plans for the primary mission. Publication and distribution will be accomplished upon receipt of the signed approval page from NASA.

B. DSN Operations Plan

The final approved version of the DSN Operations Plan for MVM'73 was distributed in late September 1973. Any future changes required will be accomplished via Special Instruction Message to the appropriate operational area.

II. Program Control

A. DSN Operational Readiness Review

The DSN Operational Readiness Review for MVM'73 was conducted on September 26, 1973, as scheduled. This was the last in a series of DSN-sponsored reviews for the MVM'73 Project. The purpose was to review and evaluate the state of DSN readiness to support MVM'73 mission operations, and to determine and assign actions needed to meet readiness objectives. Achievement of DSN operational readiness included:

(1) Completion and verification of required data system configurations.

(2) Verification of proper system performance.

(3) Verification of interface compatibility between the DSN and the spacecraft, Mission Operations System (MOS), and Mission Control and Computing Center (MCCC).

(4) Publication and verification of mission dependent procedures.

(5) Completion of training of DSN operators and crews.

(6) Failure, discrepancy and problem analysis, and corrective action.

The scope of the review encompassed all committed DSN capabilities, including NASA communications services that support the DSN and Project. Presentations were made in accordance with the agenda given in Table 1. The Review Board, shown in Table 2, met in closed session following the presentations to assess problem areas and assign action items. Particular attention was given to continuing DSN implementation tasks (S/X-band and planetary ranging) and to problem areas wherein the quality of DSN system performance does not meet specifications (telemetry data records). Meetings have been held twice weekly to review progress and the closure of action items.

B. JPL Director's Review

On October 19, 1973, the MVM'73 Project Systems, including the spacecraft, Mission Operations, Mission Control and Computing Center, and the DSN, presented reports on the status of MVM'73 preparations to the JPL Director and Deputy. Emphasis was placed on problem areas and their potential impact on launch readiness. The DSN input to this review consisted of an update and summarization of pertinent material from the DSN Operational Readiness Review. The major area of concern in the DSN remained the quality of DSS telemetry original data records.

Of primary concern on a broader scale was the question of ability to achieve objectives and provide satisfactory support in the face of severe loading of JPL resources by Pioneer 10 encounter, MVM'73 launch/encounters, Pioneer 11 support, and Helios/Viking development. Figures 1 and 2 illustrate the DSN plan for subnetwork and Deep Space Station (DSN) sharing required to meet Pioneer 10 and MVM'73 objectives. Operationally this is a difficult plan to execute, and it alters standard practices regarding DSN configuration control and configuration freezes for critical phases.

C. MVM'73 Launch Readiness Review

The MVM'73 Project conducted the Launch Readiness Review on October 26, 1973. The Tracking and Data System (TDS) presentation included status of both the near-Earth and DSN elements. Material presented included planned launch/near-Earth support, support readiness status, problem areas and constraints, and DSN-spacecraft compatibility final report. Although work continues on certain DSN problem areas, it was concluded that required capabilities have been demonstrated and are green for launch (see Table 3).

D. Status Reviews and Reports

Each morning at 7:30 a.m. during October 1973, the Project, Mission Control and Computing Center, and DSN met to review the status of items on the "Critical Lien List." Troubleshooting and test activities within the DSN have concentrated on items in this list. As a result, only one item remains open: telemetry original data record quality has not been satisfactorily demonstrated at all DSSs.

At launch minus 30 days, the DSN initiated weekly status reports via teletype to NASA Headquarters. This was changed to daily reports at launch minus 10 days. These reports will continue through completion of the first trajectory correction maneuver (TCM) at launch plus 10 days.

III. Implementation Activities

A. Ground Communications

During this report period, installation of 28.5-kilobits/s wideband capabilities was completed, including CTA 21. Activation of the wideband circuit to DSS 43 was accomplished earlier than planned to permit transmission of high-rate data during Project operational demonstration tests in early October 1973. In many early tests the quality of wideband data was poor. This was first thought to be due to degraded circuit performance; however, later tests isolated the trouble to a phasing problem between the wideband coded multiplexer transmit and receive clocks. With two clocks (receive and transmit) running at each end of the circuit, phase crossings introduced errors resulting in frequent invalid wideband data blocks. This produced severe data dropouts in the long-loop simulation mode. A work-around was devised for test support purposes wherein the central communications terminal receive clock was slaved to the transmit clock and one clock was inhibited in each coded multiplexer at the DSS. This problem only affects operations in the long-loop simulation mode and has no impact on normal mission operations. A permanent fix is being designed to resolve the clock problem.

During October 1973, an additional high-speed data terminal was added at the central communications terminal making a total of twelve. This should ease the cir-

cuit scheduling difficulties caused by the heavy MVM'73 and Pioneer loads.

All communications implementation for MVM'73 is completed, and all subsystems are green for launch/mission support.

B. Deep Space Stations

Implementation of capabilities planned to be available prior to launch have been completed. However, hardware failures have precluded accomplishment of all objectives during test activities. Most hardware problems are associated with assemblies in the DSS telemetry string, particularly Data Decoder Assemblies and digital recorders. Actions being taken to resolve these problems are discussed below. Significant progress was also made toward completion of other capabilities (S/X-band and planetary ranging) committed to be operational at later dates.

1. Telemetry and command data subsystem (TCD). Revision A of the TCD software program completed the acceptance test and was transferred to operations on September 14, 1973 as scheduled. System performance tests with this version are essentially complete at all DSSs at this time.

Data Decoder Assemblies (DDAs) have experienced frequent faults and long mean time to repair. Also, improper performance introduces errors into the real-time and recorded telemetry data. The major cause was determined to be faulty selector channels. New selector channels have been installed in the DDA at each 64-m DSS, and installation has been initiated at 26-m DSSs. The replacement of selector channels will continue through November 1973. Capacitors have been added to the old selector channels at all DSSs to change and correct the address counter timing. This upgrade has significantly improved data quality and appears to have significantly increased the DDA reliability.

Poor quality of TCD telemetry digital original data records (ODRs) is the most serious DSN problem at this time. The telemetry ODR is the prime source of data for MVM'73 data records production. The problem is that the ODR does not meet the $\geq$99% good data criterion due to various error sources. Tape deck misalignment is a major source of error and causes incompatibilities with Mission test computer read capabilities. Faulty DDA selector channels are a major source of tape read/write error indications. Insufficient maintenance and operator errors have been contributors. Improper operation of the recorder write/read/rewrite error detection circuitry logic appears to be a minor source of errors. In addition, infrequent but serious time-tag errors have been observed.

Each of these ODR problems is being worked and a comprehensive validation program is in process wherein each recorder supporting MVM'73 is being verified. Tape decks at all DSSs have been aligned in accordance with a special procedure. Telemetry system performance tests have been run following alignment to verify results on-site. Tapes produced at the DSS are being shipped to JPL for content and compatibility verification. The DSS prepass countdown now includes items for tape recorder checks and minor maintenance. DDA selector channels are being replaced. Training continues to reduce operator errors. A fix is being designed for the error detection circuitry logic and will be implemented in November 1973. A special diagnostic program has been prepared and distributed for DSS use in detecting suspected erroneous counts in the DDA binary time of day counter. Each DSS is examining the 100-pulses/s input to the binary counter for noise and the source of extraneous counts that can be corrected with appropriate impedance. Additional operational procedures are being considered and developed to assure continued production of high quality ODRs throughout the mission. Results to date are very encouraging in that most ODRs have shown a 20% improvement in data quality and are within specification.

2. Tracking data handling subsystem (TDH). Significant progress was made on implementation of planetary ranging capabilities during September–October 1973. Installation at DSS 71 was completed in October, and planetary ranging tests were conducted with the flight spacecraft on October 23, 1973. Compatibility was verified and range numbers were as expected. Installation was completed at DSS 12 and final system tests are in process to verify planetary ranging end-to-end performance. Planetary ranging assemblies were shipped to DSSs 43 and 63 ahead of schedule. Implementation at these stations must work around the configuration freeze for Pioneer 10 encounter in December 1973. It is expected that planetary ranging overseas will be operational by January 1, 1974, as planned.

3. S/X-Band Equipment. Installation of the MU_2 ranging assembly at DSS 14 on October 22, 1973, marked completion of all installation required for S/X-band. This includes the Block IV Receiver/Exciter Assembly, Dual Doppler Assembly, and zero-delay device. However, the Command Modulation Switch Assembly was not installed for reasons stated below. S/X-band subsystem level test-

ing has been initiated. Testing, training, calibration, and evaluation for S/X will be carried out according to the baseline schedule shown in Fig. 3. This plan and schedule were negotiated between the Project and DSN.

The Command Modulator Assembly (CMA) switch was required as a part of the S/X implementation to provide for uplink commanding capabilities through either the Block III or the Block IV exciter. Figure 4 illustrates the current DSS 14 configuration for operational S-band uplink commanding. This configuration is under strict control for Pioneer 10 encounter critical command operations. Figure 5 illustrates the planned DSS 14 Block III/Block IV uplink configuration after addition of R&D assemblies having S/X-band capabilities. The CMA switch is a key component in providing for MVM'73 simultaneous commanding and ranging modulation via the Block IV exciter.

Alteration of DSS 14's command configuration at this time was challenged. Therefore, prior to installation approval, the appropriate people met on September 28 to review the switch design, operational characteristics, and proposed configuration. A number of factors were discussed (design, quality assurance, spares, documentation, test plans, reliability, operational procedures, and monitoring), resulting in a definite indication that the switch should not be installed at this time. Again, on September 28, the issue was discussed with the Assistant Laboratory Director (ALD) for Tracking and Data Acquisition, the Tracking and Data System (TDS) Manager, and the DSS 14 Station Manager, resulting in the decision to delay installation until completion of Pioneer 10 encounter operations. This decision would have required MVM'73 S/X operations to be handled via the configuration illustrated in Fig. 6.

The MVM'73 Project was informed of this decision on September 28. A more detailed briefing was given to the Project staff on October 1, 1973, wherein some possible work-arounds were suggested. Later on October 1, the appropriate Project and DSN people met to pursue the feasibility of alternative configurations. The recommendations from this working group were as follows:

(1) Until completion of Pioneer 10 critical encounter operations in mid-December 1973, the DSN should establish and use a configuration for DSS 14 as shown in Fig. 7. In this configuration, the MU_2 ranging assembly would interface with the Block III rather than Block IV exciter, the Block IV exciter is not used, and the commanding configuration is not changed.

(2) In mid-November 1973, the CMA switch status will again be reviewed and plans will be made for its installation per Fig. 5, or DSS 14 will be configured as illustrated in Fig. 8 in the absence of a CMA switch following Pioneer 10 encounter.

IV. Test and Training Activities

September and October 1973 were to have been devoted primarily to Mission Operations System tests and the support thereof. However, ground data system problems and their resolution were given priority. As a result, many of the planned Project operational demonstration tests and operational readiness tests were converted to data system tests. Critical problems were cleared and satisfactory support was provided for the Project launch/near-Earth operational readiness test during the week of October 22, 1973. A final operational readiness test is planned during the week of October 29 just prior to launch. DSN testing and training for MVM'73 standard capabilities have been completed. A continuation is, however, required to achieve performance verification and operations proficiency in the areas of planetary ranging and S/X-band operations.

Final DSN-spacecraft compatibility tests were conducted at DSS 71 on October 23, 1973. All telemetry modes, commanding, and ranging were verified. Compatibility has been demonstrated; however, detailed analysis of test results is still in process.

Table 1. Agenda for Operational Readiness Review for MVM'73

Topic	Speaker
Opening comments	N. A. Renzetti, Chairman
Introduction	E. K. Davis
Path to DSN readiness	
Review Board introduction	
Review purpose and scope	
Review procedure	
Review agenda	
Overview material	
Configuration diagrams	
Implementation identification	
DSN implementation status	
DSN equipment delivery and problem resolution	
DSS equipment	P. T. Westmoreland
GCF equipment	R. H. Evans
DSS 14 S/X-band	R. L. Weber
DSN equipment installation/ ECO status	C. W. Harris
DSN test and training	
Overview	
DSS system performance tests	
Tracking	G. D. Barnes
Telemetry	R. D. Rey
Command	B. Falin
Monitor	A. Caticchio
Network level test/training	C. W. Harris
OVT/PDT	
Training	
Interface testing	
DSN-spacecraft compatibility	A. I. Bryan
Ground data system	R. G. Polansky
Network operations status	C. W. Harris
Review Board Session	

Table 2. Review Board for Operational Readiness Review

Board title	Name, position
Chairman	N. A. Renzetti, TDS Manager for MVM'73
Member	V. C. Clarke, Mission Analysis and Engineering Manager for MVM'73
	E. K. Davis, DSN Manager for MVM'73, Review Coordinator
	E. C. Gatz, DSN Systems Engineer
	C. W. Johnson, DSN Representative for the Applied Mechanics Division
	R. K. Mallis, DSN Operations Manager
	R. G. Polansky, Ground Data System Engineer for MVM'73
	M. J. Sander, MCCC Manager for MVM'73
	N. Sirri, MOS Manager for MVM'73
Secretary	Billie J. Weir

Table 3. DSN planned launch/near-Earth support

DSS	Event
42	Initial acquisition; Real-Time Computing System predicts prime
	Telemetry: 2450 bits/s; receive, record, real-time transmission
	Command: as soon as possible after two-way lock; automatic/manual backup
	Radio metric: doppler, angles, Mark IA lunar ranging Communications: one high-speed data line (HSDL), two teletypes (TTY), one voice
62	Normal support, no critical events
	Telemetry: 2450 bits/s; receive, record, real-time transmission
	Command: automatic/manual for contingency
	Radio metric: doppler, angles, Mark IA lunar ranging
	Communications: one HSDL, two TTY, one voice
14	Prime, real-time 117 kilobits/s Earth/Moon TV and 2450 bits/s
	Telemetry: 117 kilobits/s and 2450 bits/s; receive, record, real-time transmission
	Command: automatic required, high activity TV sequence
	Radio metric: doppler and angles
	Communications: one wide-band data line (WBDL) at 230 kilobits/s, one WBDL at 28.5 kilobits/s, one HSDL, two TTY, one voice
12	Backup to DSS 14 for command and 2450 bits/s telemetry
	Telemetry: 2450 bits/s; receive, record, real-time transmission
	Command: on-line backup to DSS 14
	Radio metric: doppler, angles; planetary ranging if used prime two-way
	Communications: one HSDL, two TTY, one voice

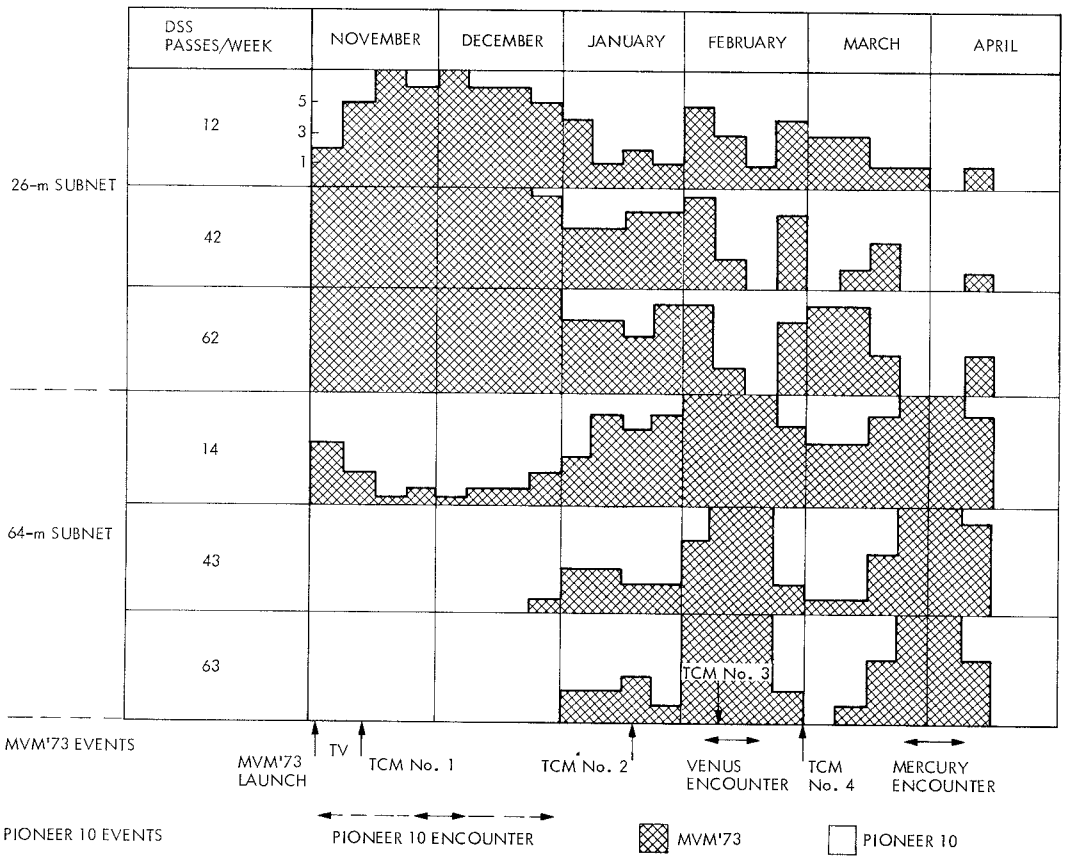


Fig. 1. MVM'73/Pioneer 10 subnet use schedule

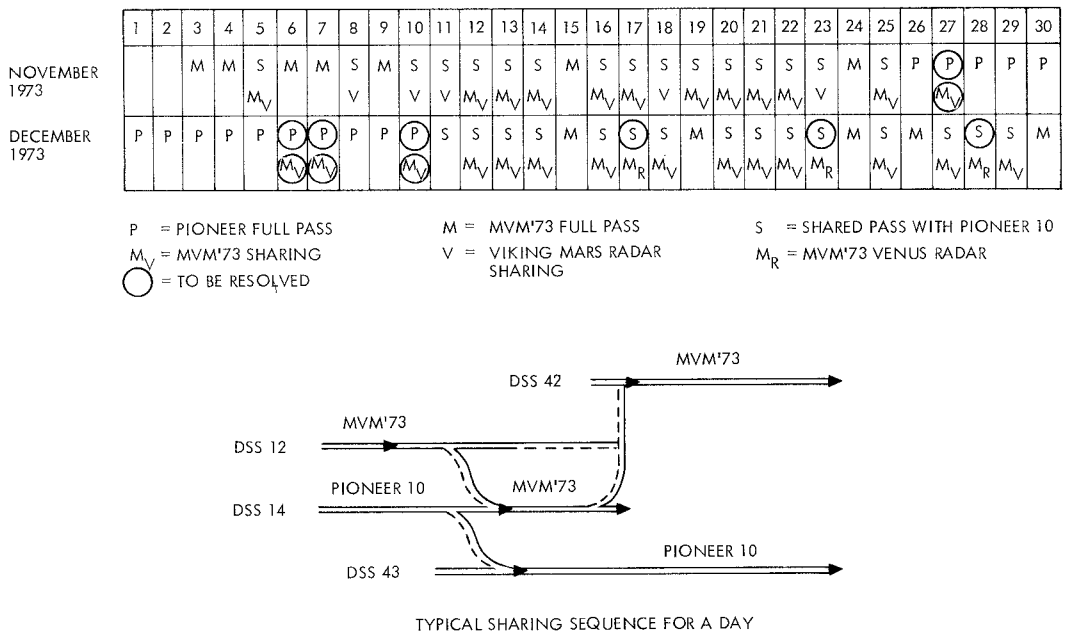


Fig. 2. Pioneer 10/MVM'73 sharing plan for DSS 14

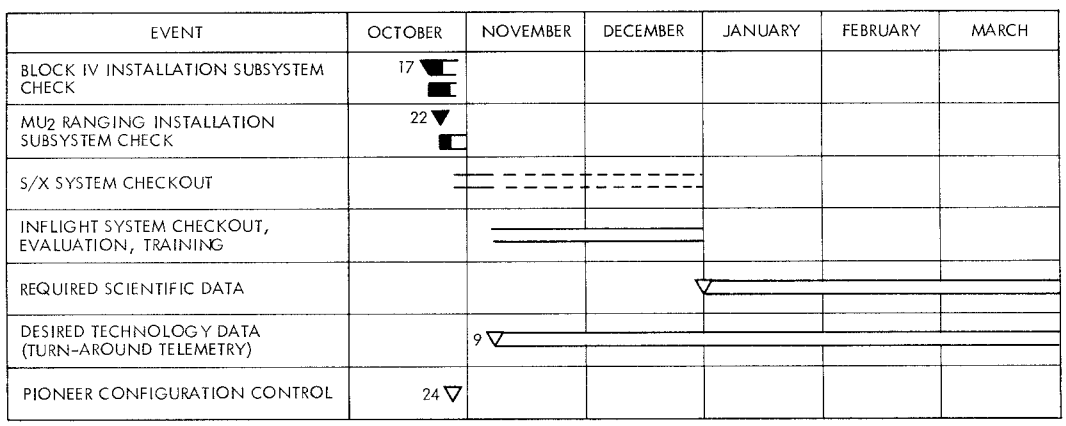


Fig. 3. DSS 14 S/X-band implementation schedule

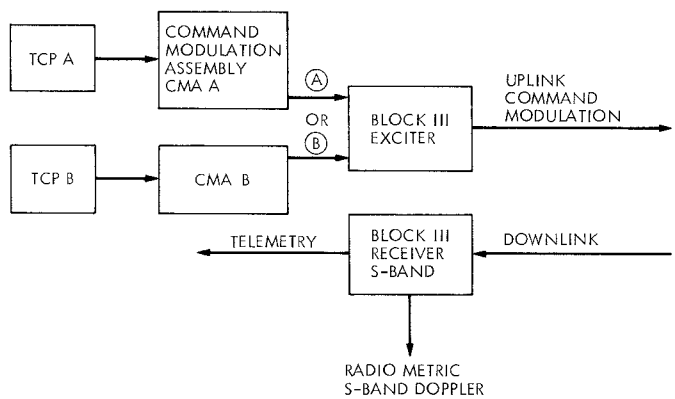


Fig. 4. Current DSS 14 Block III configuration

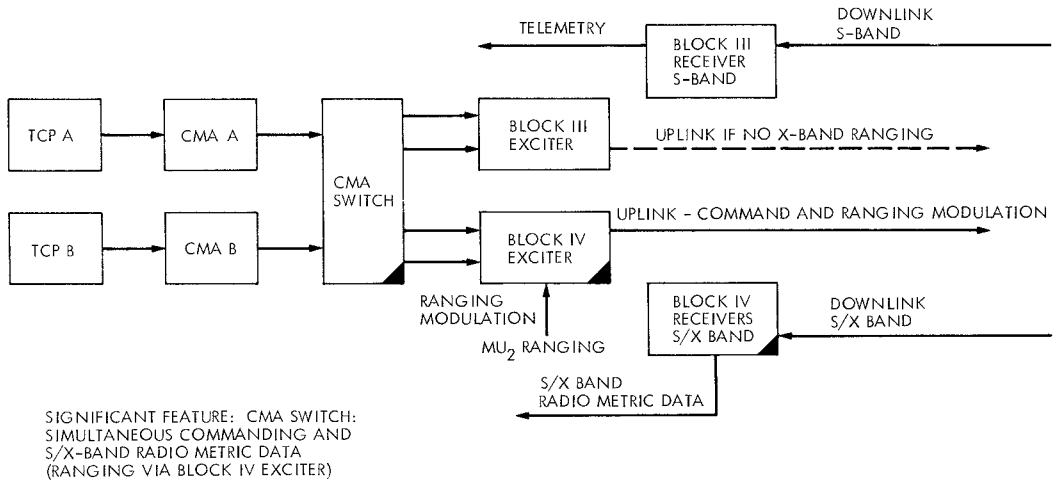
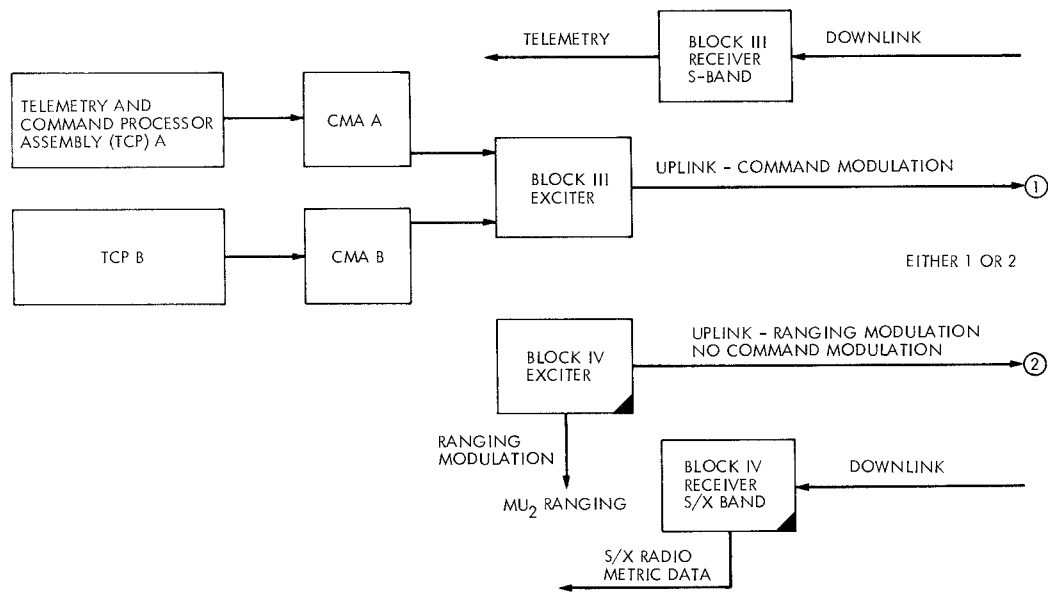


Fig. 5. Planned DSS 14 joint Block III/Block IV S/X-band R&D configuration for MVM'73



KEY CHARACTERISTICS:

NO CMA SWITCH
ALL COMMANDING THROUGH BLOCK III EXCITER
NO SIMULTANEOUS COMMANDING AND S/X RADIO METRIC (RANGING) DATA

Fig. 6. DSS 14 Block III/Block IV configuration as result of CMA switch decision

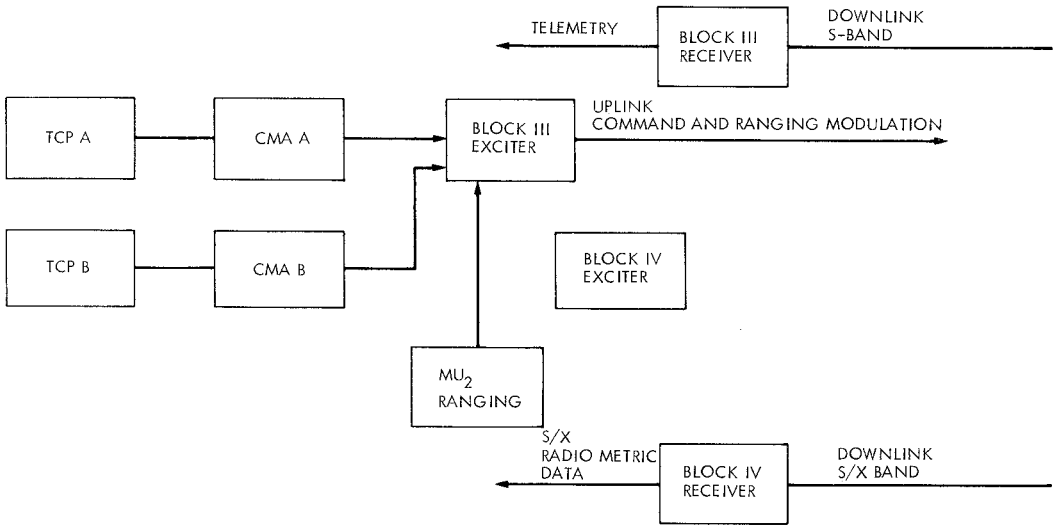


Fig. 7. Alternate DSS 14 configuration recommended through Pioneer 10 encounter

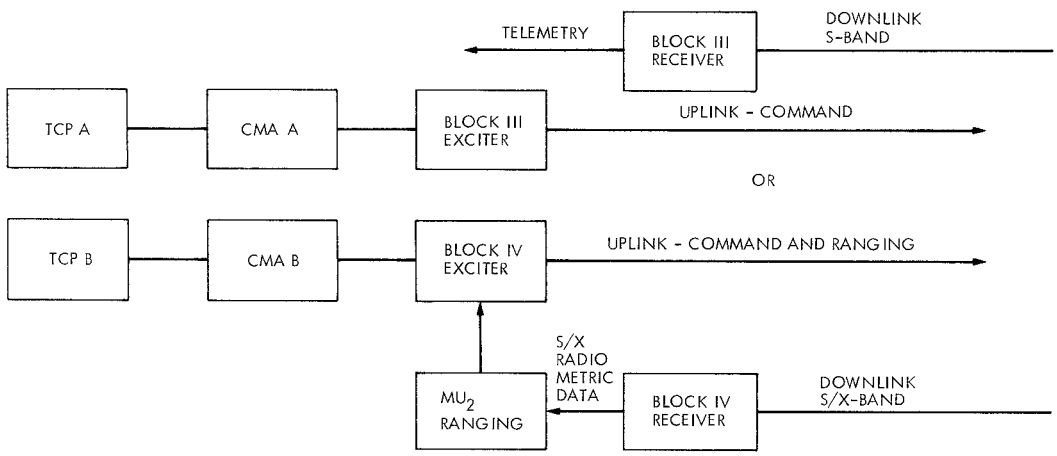


Fig. 8. Alternate DSS 14 configuration, after Pioneer 10 encounter without CMA switch